

# Natural and anthropogenic threats to California's endemic foxtail pine (*Pinus balfouriana*)



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## Background

California is unique in its white pine diversity, with six of the nine North American species distributed across a range of montane ecosystems. White pine blister rust (WPBR), caused by the exotic pathogen *Cronartium ribicola* J.C. Fisch., severely threatens white pine sustainability in the Western US. When coupled with climatic warming (e.g., protracted drought periods) and climate-driven outbreaks of native insects, such as mountain pine beetle (*Dendroctonus ponderosae*; MPB), these stressors pose significant challenges to high-elevation forests. In California, WPBR has been found in four of the six white pine species, including California's endemic foxtail pine (*Pinus balfouriana*). Noteworthy of foxtail pine is its limited, disjunct distribution at high elevations in the northern coast-interior and southern Sierra Nevada mountains. This geographic separation also corresponds to genetic differences with the recognition of a northern and southern ecotype. In the north, foxtail stands are also genetically diverse from one another, have small population sizes, are at their ecological limits, and located in a distinctive geological-vegetation complex of California. In the southern Sierra Nevada this species can be in isolated populations or form extensive stands in subalpine forests to timberline. Like other high-elevation white pines, foxtail pine is of great value ecologically, e.g., for watershed protection, habitat and forage for wildlife, and cultural and aesthetic values.

Data from a recent California high-elevation white pine survey documented rust infection on foxtail pine in plots of the northern stands, but not in the southern ones. The average infection in the north was 12% (range: 0-32%). Current information on the status of foxtail pine relies on anecdotal observations and relatively few plots. Supplementing with additional plots would provide more information on WPBR, beetle activity, and recruitment dynamics of this endemic species. Such information is basic to developing conservation and management strategies, as this species is part of the larger concern about the health of all high-elevation white pine species. Given foxtail's limited distribution, the risk of significant, more rapid loss of trees (or populations) may be higher than in the widely-distributed high-elevation white pines of California.

## Project Objectives

- Increase the number of long-term monitoring plots in foxtail pine stands.
- Develop demographic models for foxtail pine to evaluate population dynamics
- Supplement current information on white pine blister rust in foxtail pine with other stressors such as mountain pine beetle.

## Methods

➤ **Survey plots:** 30 by 50 m transect plots, with size adjustments as needed, and each plot containing at least 30 live foxtail out of 50 trees total.

1. **Tree data:** Diameter, tree status (live, dead), crown condition (% of crown dead, dying, damaged, infected), presence/absence of WPBR, canker location (stem/branch), number, and status (active or not), other rust symptoms, unknown branch flagging, other pathogens and insects, i.e., mountain pine beetle (*Dendroctonus ponderosae*), and cone production. 2. **Plot data:** Number of seedlings/saplings and their status (live/dead; rust or no rust infection), *Ribes* species (% cover in plots, rust/no rust), plot location, slope and aspect, associate tree species, aecia phenology, and presence/absence of *Castilleja*, *Pedicularis*, and Clark's nutcrackers.

➤ **Demographic plots:** Within a stand, 3 replicated plots ranging in size from 0.5 to 1.0 hectare in which tree data are collected and trees mapped. Recruitment seedlings and saplings were evaluated within each plot with 3 nested regeneration plots (15 x 15 m).

1. **Demographic data:** Tree and plot data similar to survey plots. Additional data on seedling and sapling recruits: live/dead, cause of mortality, height, diameter, whorl count, crown condition, insect and/or non-rust disease, microsite habitat, litter depth, geophysical substrate 2. **Mapping:** Foxtail regeneration mapped and tagged.

## Results

Rust was present in 5 of the 18 plots (12 plots from previous survey), and only in plots of the northern populations of foxtail pine. No rust was found in the 6 additional plots or 3 demographic plots established in 2008 (Figure 1). To date, levels of MPB and mortality are low. Seedling regeneration was higher in the northern foxtail plots (Table 1).

TABLE 1.

Ecotype	% WPBR	% MPB	% Mortality	Seedlings / 0.15 ha
Northern	9.1	1.4	1.6	15.0
Southern	0	1.8	3.0	5.5

WPBR was correlated with latitude, select climate variables, and distance to inoculum sources. Regeneration was correlated with select soil properties and climatic variables (Table 2).

TABLE 2.

	Preliminary correlates to:	
	WPBR	Regeneration
Positive correlations	Latitude	Available soil water capacity at 25 "
	September growing degree days	Soil water capacity at 15 bars
	Total annual precipitation	Minimum annual temperature
	Minimum annual temperature	Annual precipitation
Negative correlations	Distance to low elevation mixed-conifer forests (inoculum source)	

Size class distribution patterns differed for the two ecotypes of foxtail pine (Figure 2). The northern foxtail plots had high seedling numbers followed by low, relatively stable tree densities across the diameter classes. In contrast, the southern foxtail plots had low numbers in the smaller size classes and high numbers in the largest size class, suggesting little or episodic recruitment in the southern plots.

FIGURE 2.

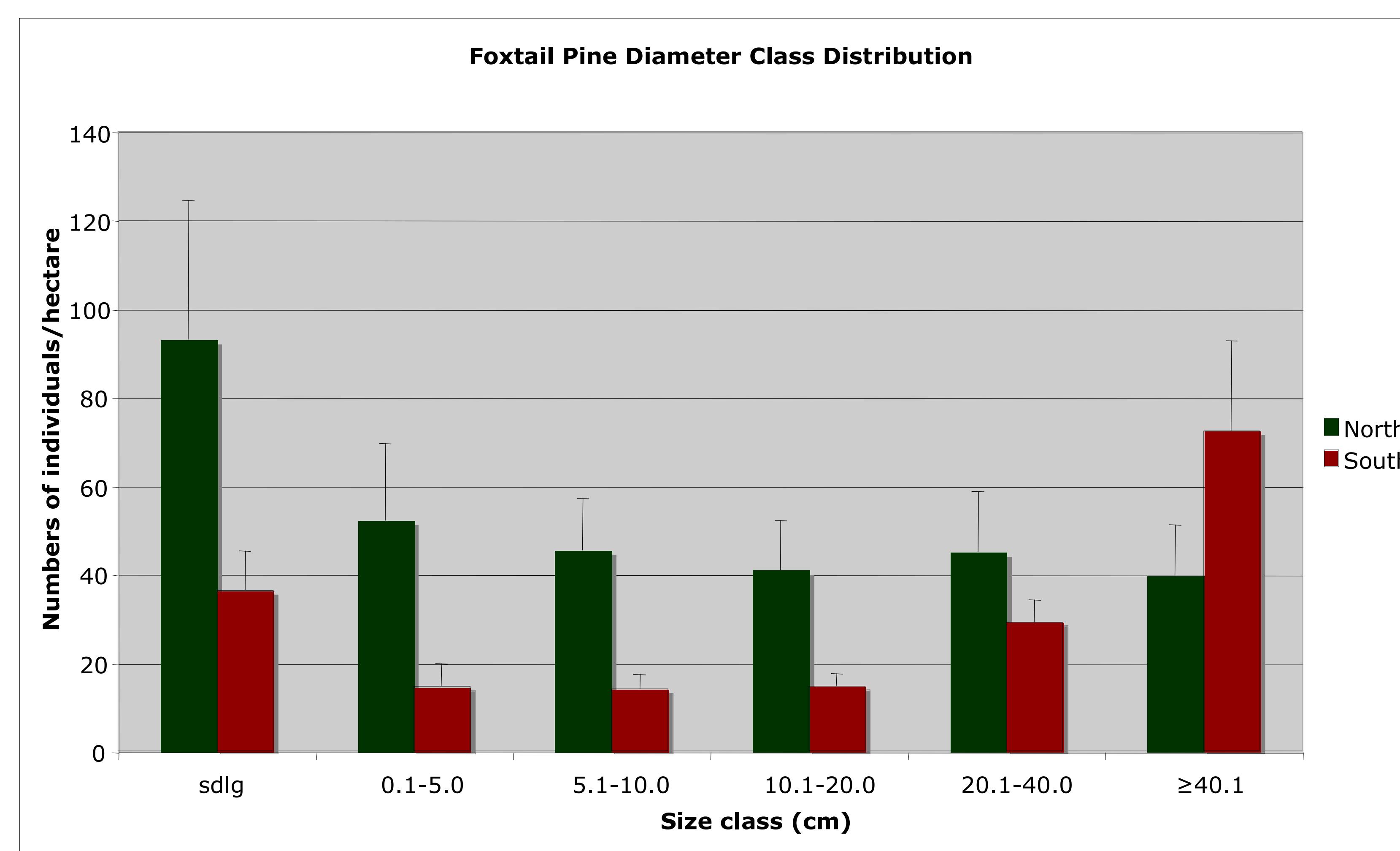
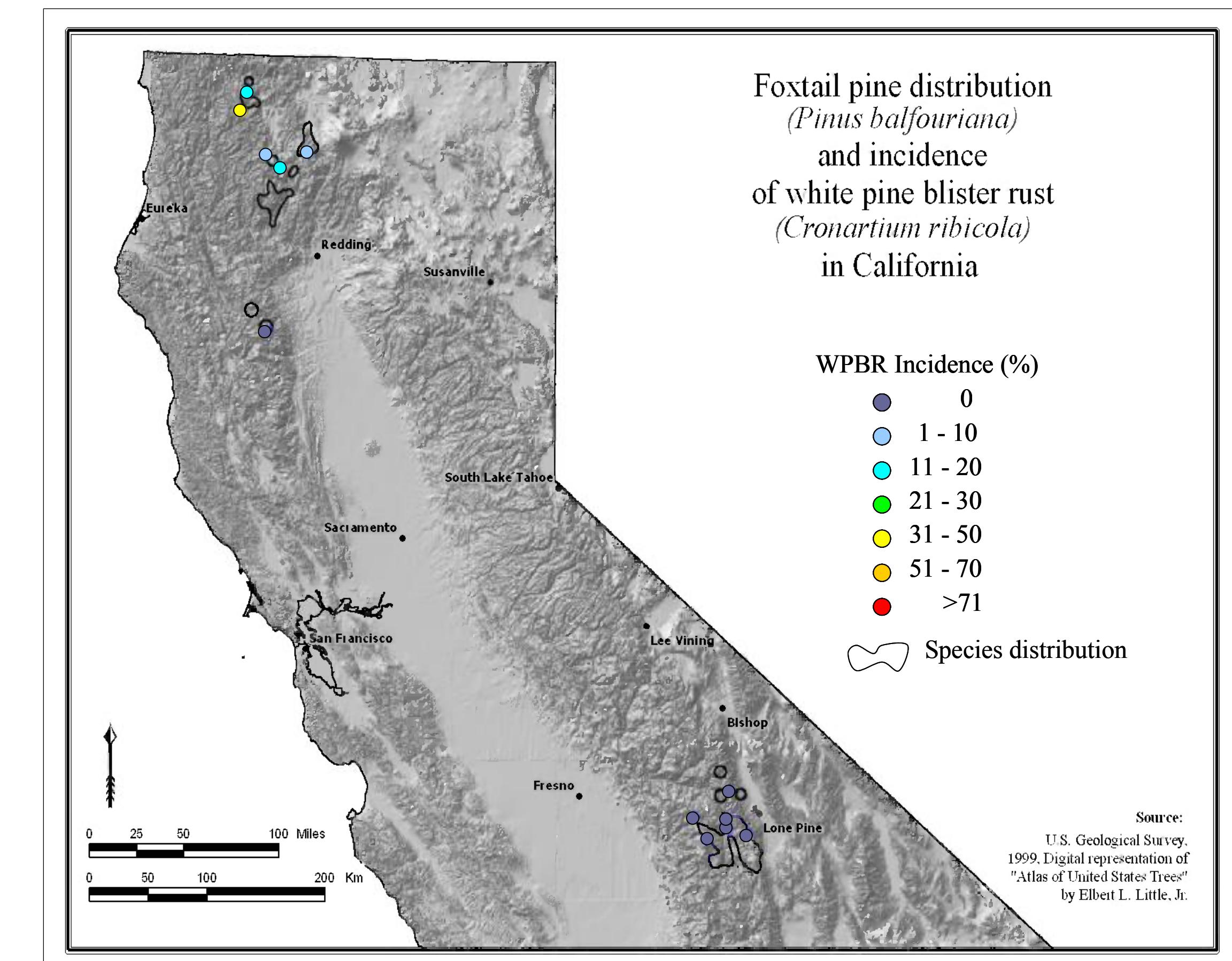


FIGURE 1.



## Looking ahead?

- Establish additional monitoring plots in 2009.
- Determine relationships between environmental and biological factors with tree responses to disease, insects, and drought.
- Develop demographic models to assess foxtail population dynamics and status (e.g., maintaining, growing, declining).
- Cone collections and seed banking.



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